Correlation analysis tool using the Schrödinger equation (CATS)*

D. Mihaylov[1] *and L. Fabbietti*[1]

[1]Physics Department E62, TU München, James-Franck-Str., 80805 Garching, Germany

Femtoscopy

The femtoscopy investigates particle correlations using the experimentally accessible two-particle correlation function $C(k)$. Theoretically $C(k)$ can be defined in terms of a source function $S(k,r)$, which describes the relative two-particle spatial distribution at thermal freeze-out, and the two-particle wave function $\Psi(k,r)$, which carries information about the interaction potential $V(r)$ between the particle species of interest (equation 1).

$$C(k) = \int S(k,\vec{r}) \cdot |\Psi(k,\vec{r})|^2 \mathrm{d}\vec{r} \qquad (1)$$

The HADES collaboration has published a femtoscopy analysis of $p\Lambda$ correlations, extracted form the experimental data collected during the 3.5 GeV pNb beam-time, which demonstrated that measuring the correlation function may be used in order to differentiate between different potentials [1]. This is a very nice proof that femtoscopy can be used, among other things, in order to expand our knowledge about hyperon-nucleon interactions. Although the currently available data does not provide enough statistics to achieve those goals, it is expected that once HADES is moved to the FAIR facility high-precision femtoscopy studies will be possible. In addition we are involved in the femtoscopy program of ALICE at LHC, which will give us the opportunity to directly compare and analyze results stemming from different collision systems.

CATS

The femtoscopic data analysis poses many difficulties. This report concentrates on one in particular, namely the theoretical modeling of $C(k)$. From eq. 1 it is evident that both the emission source and the wave-function have an influence on the profile of $C(k)$. Hence it is essential that one is capable to accurately compute $C(k)$ based on any source and potential. Solving eq. 1 analytically is feasible only for larger source-sizes and usually in the absence of Coulomb interaction (e.g. the Lednicky model [2]). Thus it is better to use numerical methods. However the currently openly available tools are either not very flexible and easy to integrate into any analysis framework or evaluate the wave-function by using certain approximations which may lead to inaccuracies when working with smaller sources.

The considerations above motivated the development of the "Correlation Analysis Tool using the Schrödinger equation" (CATS), which relies entirely on numerical methods to evaluate the correlation function. CATS is developed as a stand-alone C++ class and is designed to handle any short-range potential with or without the inclusion of the Coulomb interaction and/or quantum statistics. The wave function is computed by solving the Schrödinger equation fully numerically and thus obtaining an accurate solution event at small radii. The numerical solver has an adaptive grid which optimizes the performance. In addition CATS is capable of working with either an analytical or a data-defined source. This allows to extract the emission source from transport models. CATS is currently in test-phase but will be made available to the general public in the future. So far we have confirmed that CATS is in agreement with other theoretical calculations that are optimized to work with larger sources but starts do deviate, as expected, in the case of smaller sources (fig. 1).

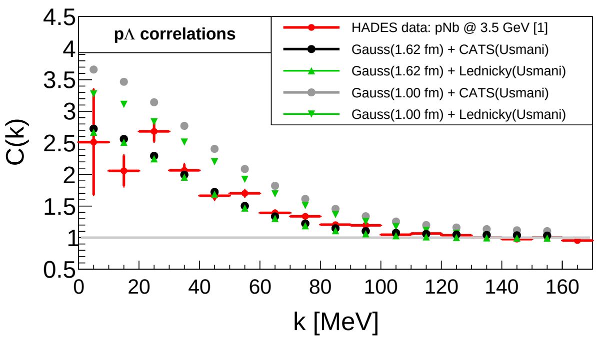

Figure 1: Comparison of the $C(k)$ predictions by different tools. The interaction is modeled by the Usmani potential. The source is assumed to have a Gaussian shape.

Summary

We have used our experience in investigating particle interactions using femtoscopy to develop a numerical tool called CATS, which allows for a fast and accurate computation of the theoretical correlation function for any source and potential. In addition this tool is very flexible which will make it a valuable asset for future femtoscopy studies.

References

[1] J. Adamczewski-Musch et al. (HADES Collaboration), Phys. Rev. C 94, 025201 (2016)

[2] R. Lednicky and V. L. Lyuboshits, Sov. J. Nucl. Phys. 35, 770 (1982)

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